11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

DYNAMIC STRESS CALCULATION IN GEAR SIMULATIONS USING REDUCED ELASTIC MULTIBODY SYSTEMS

Pascal Ziegler, Dennis Schurr and Peter Eberhard

Institute of Engineering and Computational Mechanics
University of Stuttgart, Germany
[pascal.ziegler, dennis.schurr, peter.eberhard]@itm.uni-stuttgart.de

Key words: *Reduced Elastic Multibody Systems, Stress Calculation, Gear Contact, Elastic Gears*

Traditionally, gear stages are simulated using rigid multibody systems (MBS). However, increasing lightweight design makes the model assumption of rigidness questionable and considerable flexible deformation occurs. It has been shown that in these cases an elastic formulation is necessary to precisely calculate contact forces, [1, 2]. There, it has also been shown that Finite Element (FE) models are able to give very precise results considering all elastic effects, but are computationally too expensive to simulate several contacts or even several rotations in practically acceptable time. A good trade-off is offered by an elastic multibody system (EMBS), [3]. In this work, an efficient method for the simulation of elastic gear trains will be presented using a modally reduced, floating frame of reference-based EMBS with collision detection. For the contact calculation a nodal-based penalty formulation is used, [4]. The agreement of the obtained results vary with the number and choice of shape functions used for the reduction. In this work, we will compare different types and sets of shape functions. For instance, eigenmodes, static deformation shapes and krylov based shape functions will be compared in terms of precision and computational efficiency. This will be done by means of a numerical model of a real technical gear pair.

From an engineering point of view, one of the most interesting quantity during gear design is the stress distribution in the gears during operation, particularly the stress in the dedendum. The proposed elastic approach easily allows to calculate the stress distribution by simply superimposing stress states associated with the shape function used to describe the elastic deformation. The stress recovery is a simple matrix multiplication which can be carried out in a post analysis step and, therefore, does not reduce the performance of the proposed EMBS approach and still includes all dynamical phenomena. Hence, this is not only more precise, but also much faster than the classical two stage calculation using a rigid body model first, followed by a quasi-static FE stress calculation. In this work we will further investigate to what extend the shape functions, which were found to be best for the contact calculation, are also well suited for a precise stress calculation. Also, it will be shown that the different regions of interest for the stress distribution result in a different choice of types and sets of shape functions to retain precision and efficiency of the proposed approach.

REFERENCES

[1] P. Ziegler, P. Eberhard, B. Schweizer. Simulation of impacts in geartrains using different approaches. Archive of Applied Mechanics **76**, 537–548, 2006.

[2] P. Ziegler. Dynamische Simulation von Zahnradkontakten mit elastischen Modellen (in German). Dissertation, Schriften aus dem Institut fü Technische und Numerische Mechanik der Universität Stuttgart, Shaker Verlag, Aachen, 2012.

[3] A.A. Shabana. Dynamics of Multibody Systems. Cambridge University Press, Cambridge, 2005.

[4] P. Wriggers. Computational Contact Mechanics. Second Edition, Springer, Berlin-Heidelberg, 2006.